Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

SHOUT
SHARE
IT

1
E465B
cop. 3

H. P. Cowgill

Issued January 22, 1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

LIBRARY
RECEIVED
MAR 27 1916
U. S. DEPT. OF AGRICULTURE

Bulletin No. 19.

COVER CROPS FOR PORTO RICO.

BY

C. F. KINMAN,
Horticulturist.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

Issued January 22, 1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

Bulletin No. 19.

COVER CROPS FOR PORTO RICO.

BY

C. F. KINMAN,
Horticulturist.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Agronomist in Charge.*
P. L. GILE, *Chemist.*
E. W. BRANDES, *Plant Pathologist.*
C. F. KINMAN, *Horticulturist.*
R. H. VAN ZWALUWENBURG, *Entomologist.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., August 16, 1915.

SIR: I transmit herewith a manuscript on Cover Crops for Porto Rico, by C. F. Kinman, horticulturist.

As nitrogen is the limiting factor in the fertility of Porto Rican soils and these soils are generally deficient in humus and subject to great loss of fertility due to the action of the hot sun and heavy rains of the Tropics, which cause a rapid decay of organic matter and loss of fertility by erosion, the growing of leguminous cover crops results in a double benefit and should be widely practiced in the island.

I respectfully recommend that this manuscript be issued as Bulletin 19 of the station.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	9
Selection of a cover crop	10
Cover crops recommended for Porto Rico	11
Cowpea (*Vigna catjang* or *V. sinensis*)	11
Canavalias	12
Jack bean (*Canavali ensiformis*)	12
Sword bean (*Canavali gladiata*)	13
Stizolobiums	15
Lyon bean (*Stizolobium niveum*)	17
Bengal or Mauritius bean (*Stizolobium aterrimum*)	17
Stizolobium cinereum	18
Stizolobium velutinum	18
Florida velvet bean (*Stizolobium deeringianum*)	19
Pigeon pea or gandul (*Cajanus indicus*)	20
Valuable wild leguminous plants	21
Mani cimarrona (*Chamæcrista diphylla*)	21
Matraca (*Crotalaria retusa*)	22
Zarzabacoa galana (*Desmodium adscendens*)	22
Zarzabacoa común (*Desmodium incanum*)	23
Habichuela cimarrona (*Phaseolus adenanthus*)	23
Yerba rosario (*Æschynomene americana*)	23
Conchita peluda (*Centrosema pubescens*)	24
Tamarindillo (*Cassia chamæcrista*)	24
Habichuela parada (*Phaseolus semierectus*)	24
Mato de la playa (*Canavali obtusifolia*)	25
Cover crops for citrus orchards	25
Leguminous crops for coconut groves	26
Cover crops with pineapples	28
Cultural practice	30
Summary	31

ILLUSTRATIONS.

Page.

PLATE I. Fig. 1.—Jack bean (*Canavali ensiformis*). Fig. 2.—Sword bean (*Canavali gladiata*)..... 16

II. Fig. 1.—Typical clusters, pods, and beans of six varieties of Stizolobium. Fig. 2.—Pigeon peas as temporary windbreak for young citrus orchards..... 16

III. Fig. 1.—Lyon bean (*Stizolobium niveum*) on heavy soil. Fig. 2.—*Stizolobium velutinum*, S. P. I. No. 24657, on heavy soil..... 16

IV. Fig. 1.—Matraca (*Crotalaria retusa*). Fig. 2.—Habichuela cimarrona (*Phaseolus adenanthus*)..... 16

V. Fig. 1.—Zarzabacoa galana (*Desmodium adscendens*). Fig. 2.—Zarzabacoa común (*Desmodium incanum*)..... 24

VI. Fig. 1.—Yerba rosario (*Æschynomene americana*). Fig. 2.—Conchita peluda (*Centrosema pubescens*)..... 24

VII. Fig. 1.—Tamarindillo (*Cassia chamæcrista*). Fig. 2.—Habichuela parada (*Phaseolus semierectus*)..... 24

VIII. Fig. 1.—Stizolobiums as cover crops in coconut plantation. Fig. 2.—Same field after drying of vines..... 24

COVER CROPS FOR PORTO RICO.

INTRODUCTION.

The term cover crop as used in this discussion is intended to designate a crop to be grown on soils devoted to horticulture, for the purpose of excluding wild vegetation, preventing surface washing, to shade and enrich the soil, and to improve its mechanical condition. Until within the past 10 years cover cropping was seldom heard of in Porto Rico and practiced only in a few instances, if at all. It was practiced first by the Americans who came to the island after its occupation by the United States and who undertook to establish commercial citrus-fruit groves. The absence of the most suitable plants to use as cover crops and the meager knowledge of promising wild plants were largely responsible for the lack of their appreciation by the farmers in former years. In some parts of the island cover crops are seldom seen, though their culture is rapidly increasing and should be much more general.

The need for cover crops is seldom more clearly noted than in the localities of Porto Rico where horticultural interests have been developed. The heavy rains and intense heat from the sun hasten the decay of vegetable matter and in most localities the soil is deficient in humus, as the surface soil with the decaying vegetation is carried off in surface washes. In this condition the sandy soils dry out quickly in seasons of drought and the surface of the heavy soils becomes dry and hard in dry weather and is water soaked and sticky, due to poor filtration, during periods of heavy rains. The varying soil and rainfall conditions existing in different parts of the island, the peculiar needs of the several horticultural crops, and the variation in habits of growth and length of season required for the maturity of the cover crops, emphasize the necessity for a thorough knowledge of the plants to be employed if the best results are to be obtained.

The work of securing and testing plants for cover crops to find suitable kinds has been carried on for a number of years by the experiment station. While the greater part of the testing and cultural work has been conducted at the experiment station at Mayaguez, all those that have been recommended for cultivation, together with a

11434°—16——2

number of others which appear to be less promising, have been cultivated in other parts of the island in cooperation with plantation owners. The cooperative work has proved valuable in many localities and resulted in the more extensive planting of the suitable leguminous crops.

SELECTION OF A COVER CROP.

Any quick-growing crop which will make a thrifty top and root growth and will not, if it escapes cultivation, become a weed, may be used as a cover crop. In most localities of Porto Rico any such crop is preferable to clean cultivation. The selection of the plant will depend upon its resistance to disease and insect enemies, its vigor in seasons when desired, its habits of growth, and what it returns to the soil. Since nitrogen is an expensive fertilizer element and one which is present in comparatively small quantities in most Porto Rican soils, the choice will be from the number of leguminous plants which, in addition to the good qualities of other plants used for cover crops, have the power of storing in the soil nitrogen which they take from the atmosphere.

The selection of legumes suited to the peculiar needs of the fields in which they are to be grown is of great importance in Porto Rico, as there is a great variety of soil types, a wide range of rainfall for different sections, and a great difference in the length of the growing season and habits of growth of the different plants, which suit them to a peculiar condition. Soils devoted to horticulture here are of two general classes—the light, sandy types, and the heavy, clay loams. The surface of both is subject to drying out quickly when rainfall ceases, and should be protected from the intense sun heat throughout the long summer. Vegetable matter is needed for binding the sandy types, for loosening the heavy ones, and for enriching both, and a vigorous grower should be planted to supply it. The heavy soils are, as a rule, poorly drained and require a crop that will thrive under such conditions, while those for sandy areas must resist the short, intermittent droughts and be capable of sending out a large root system which will enable them to thrive where the fertility is low. An extensive root system is needed also to prevent surface washing which in every locality results from the heavy rains.

Although in some localities the winter drought is severe, the season when rainfall is plentiful is sufficiently long for the normal development of all the annual species discussed in this bulletin. The long seasons of heavy rainfall make it necessary in localities where that condition prevails to employ a late-maturing crop, as the seed of the early-maturing crops often decay before sufficiently mature to harvest and the dying plants leave the field unprotected or free to grow harmful vegetation at a time when cultivation is not practical.

COVER CROPS RECOMMENDED FOR PORTO RICO.

Leguminous crops, which have been under observation for a few years and found to be valuable cover or manure crops, include cowpeas, jack beans, sword beans, pigeon peas, a number of species of velvet beans, and several wild plants which have been introduced into cultivation. The following discussions of the habits of these crops are given to point out the characteristics which make them suited to economic conditions.

COWPEA (*Vigna catjang* or *V. sinensis*).

The cowpea has been grown in all parts of Porto Rico for many years and is one of the most widely known of the legumes cultivated as cover crops. The object of its culture has not been exclusively to enrich the soil or improve the conditions for the growth of other crops, but to procure edible pods and seeds as well.

In consideration of its rapid development, its bunchy rather than climbing habit of growth, the ease with which it can be worked into the soil, and its food value, the cowpea is a favorite legume for growing in both coconut groves and citrus orchards where the soil is sandy and on other soils where conditions are favorable and an early maturing crop is desired.

The roots of the cowpea are slender and have but little effect in loosening heavy soils, but are well set with tubercles. The growth of the plants is very different from that in the North, for here they often produce vines which grow to 5 or 6 feet in length.

Of the various cover or soiling crops which have been under observation, the cowpea has been found to be one of the most sensitive to excessive rains, drought, and unfavorable soil conditions, and therefore is not so generally planted over the island or throughout the year as are some others. It makes its best growth if planted in spring or summer, though in fall or winter it thrives in a light, sandy, open, well-drained soil where there is a regular and moderate rainfall during its germinating and growing period. It fails in dry, hard, or water-soaked places.

At the experiment station at Mayaguez, where the soil is heavy and the rainfall is, at intervals from June until December, excessive, and where protracted droughts often occur from December until April, the only times cowpeas have made an invariably satisfactory growth have been when plantings were made in March or April. Good crops have resulted from February and May plantings. When planted March 24 the plants made an excellent growth and produced a good crop of seeds. The first pods from this planting matured June 1 and the harvest continued until July 10, after which the

plants soon died. Plantings made from July 1 to November 15 have resulted in almost complete failures. The summer plantings failed as a result of the excessive moisture in the soil and the later ones because of heavily packed soils at the time of seeding and the severe drought following. Winter plantings have given fair seed crops on the heavy soils, but drought prevented a thrifty plant crop. When the crop ripens during the months of heaviest rainfall the benefit derived is very small, as the leaves fall from the plant soon after the blossoms appear, leaving the barren stalks, which soon die. The growth is very succulent and soon decays. As cultivation is impracticable, due to the moisture in the soil, the field is left to weeds and grass. In sandy soils near Mayaguez, cowpeas have given good results when planted from April to September, but when planted from November to February the vines have made practically no growth. In parts of the island where the rainfall is sufficient throughout the year good crops have resulted on sandy soil from plantings made at any season of the year, although those made from October to February are not so profitable as in other seasons.

Broadcasting is the method usually employed in seeding sandy soils, but in heavy lands, where native vegetation and the hardening of the surface soil retard the growth of the crop, drilling in rows, so that cultivation can be given, is more satisfactory.

Tests in different localities have demonstrated that the varieties Clay, Whippoorwill, and Red Ripper make the best growth and are generally most satisfactory.

CANAVALIAS.

The Canavalias have been known in Porto Rico for many years, but not until the species *Canavali ensiformis* and *C. gladiata* were introduced into cultivation, after the American occupation, have any of the species been considered of economic importance. During the last few years these two species have become well known and their value as cover crops has been demonstrated in every locality where horticultural crops are cultivated commercially.

JACK BEAN (*Canavali ensiformis*).

This species was introduced by the experiment station in 1907 and soon became a favorite among the planters as a cover and green manure crop. Up to the present time it has been more extensively grown than all other cover crops in Porto Rico combined. It has been tested in practically all soils where citrus fruits are grown, and proves to be well suited to a wide range of soil types. It makes the heaviest growth on a well-aerated clay loam, but excellent crops have been grown on heavy clays and a growth superior to most cover crops

obtained on fertile sands. (Pl. I, fig. 1.) On poor, light, sandy soils it is not successful. The season required for the maturity of this species is shorter than for the other Canavalias or other crops under discussion here excepting the cowpea. When planted in spring or early summer when there is sufficient rainfall seed ripen in 17 weeks. When planted in the fall and grown during the dry weather seed ripen in 15 weeks. The harvest always extends over several weeks. The spring and summer plantings result in heavy crops, but when grown during dry weather a small plant growth and a heavy crop of seed will result. As a cover crop only spring and summer plantings are recommended in the western and southern sections of the island, while in the northern section, where the rainfall is more evenly distributed throughout the year, fall and winter plantings have resulted in a growth very satisfactory for a cover or soiling crop.

The jack bean has an extensive and penetrating root system, which makes it valuable for preventing washing, and the roots have a heavier nodule formation than any of the other legumes which are used for cover crops in Porto Rico except the sword bean. In habit the plant is low and bushy, growing from 2 to 4 feet in height, vines but little, and makes a vigorous growth. Its heavy growth makes a dense shade and thus prevents the growth of weeds and provides a good quantity of vegetable matter. The growth that may be expected under good conditions may be judged by the following: Fifty days after planting, the crop from a number of representative sections in a field was harvested and weighed and estimated to be 12.4 tons per acre. This harvest, when thoroughly sun dried, weighed 2.56 tons per acre. The long hanging seed pods often reach the ground, and when ripening in rainy seasons should be harvested as soon as they turn brown to prevent them from decaying.

Seeding may be done either by broadcasting or planting in rows, but row planting is preferable, where the field is not free from weeds, so that cultivation can be given for the first few weeks. On heavy soils at Mayaguez the most satisfactory crops were obtained by planting the seed from 5 to 7 inches apart in the row and spacing the rows 3 to 3½ feet apart. Planted at these distances, from 80 to 100 pounds of seed are required per acre for an open field, and proportionately less for orchards. the amount depending upon the tree growth.

SWORD BEAN (*Canavali gladiata*).

This species, known as the sword bean, is an old cultivated crop, and, while conditions in Porto Rico are well suited to its needs, it has been known here but a few years. The variety with large red seeds and red flowers has been grown here for several seasons and proves to be a

valuable cover or green-manure crop. This variety is very similar to the jack bean in its habits of growth, differing from it mainly in making a larger, more viny growth and requiring a longer period to mature. (Pl. I, fig. 2.) Its root system is larger and more penetrating, enabling it to withstand drought longer and to be more effective in loosening heavy soils. It is inclined to vine, but not to an extent which proves objectionable for a cover crop. Its tall and heavy growth makes it one of the most effective legumes for preventing wild growth through the orchard and one of the most valuable for supplying vegetable matter to the soil. At Mayaguez representative sections of a field were harvested and weighed 180 days after planting to ascertain the quantity of vegetable matter produced. The green weight was found to be 15 tons per acre, and the same material, when thoroughly sun dried, weighed 4.4 tons per acre.

When the plants are about 12 weeks old the lower leaves begin to fall, due to the dense shade above them, and thus a mulch is formed on the soil and a free circulation of air allowed beneath the heavy tops. The tall growth which reaches above the lower branches of the citrus trees makes it a valuable cover crop for affording wind protection in citrus orchards, as it prevents the wind from sweeping below the tree branches and maintains the quiet atmosphere in which the scale-destroying fungi thrive. It makes a slow growth in dry weather and for a cover crop should be planted in spring when the rains are sufficient for its needs. Good seed crops have been harvested from fall plantings. The long season required for the maturity of this crop makes it a desirable one in sections where the summer rainy season continues over a long period.

It should be planted in rows 3 to 4 feet apart so that cultivation can be given if needed, and the seed placed 8 to 10 inches apart in the rows. Eighty to 90 pounds of seed are required per acre for planting at these distances. When planted farther apart the individual plants make a heavier and more woody growth, but do not cover the ground so quickly and are more difficult to break down and work into the soil. Aside from its value as a cover or manure crop, the sword bean is a well-known human food.

The sword bean is commonly cultivated as a vegetable in Japan, India, Burma, Ceylon, Java, Mauritius, and apparently in Africa. In India it is eaten both by the natives and by Europeans, the variety with white seeds being the most esteemed. The young pods are prepared after the manner of snap beans and are well flavored and wholesome. Firminger considers it "about the nicest of all the native vegetables" in India. The very young pods have but little flavor, but when half grown their taste suggests mushrooms. They are best when about half grown, as the full-sized green pods are rather fibrous. The mature seeds do not seem to be much used as food, though they lack the strong odor of those of the jack bean.[1]

[1] Piper, C. V. U. S. Dept. Agr., Bur. Plant Indus. Circ. 110, p. 35.

STIZOLOBIUMS.

This group embraces the velvet bean and a number of allied plants.

The first American planters who became interested in citrus fruit growing in Porto Rico soon after the American occupation of the island introduced the Florida velvet bean into cultivation as a cover crop. Since that time it has been well known through citrus-growing sections here, although not extensively cultivated. Other species of velvet beans which are well suited to conditions here have recently been introduced through C. V. Piper, of the Bureau of Plant Industry, United States Department of Agriculture. From tests in a variety of soils these importations have been found valuable crops. In most cases they are superior to the Florida velvet bean on account of their long period of growth and heavier yield of green material and seed. Although as yet not generally cultivated, a number of species have proved to be of great value as cover and manure crops. Like the well-known Florida velvet bean, these species produce long vines which climb over other vegetation, making them undesirable for planting among other plants unless care is taken to cut the vines back. When attention is given to keep them from injuring other crops they will prove valuable for general use. For land which, after a few years of cropping, is abandoned for a season or more, as is the common practice with pineapple and sugar-cane land, the lately introduced Stizolobiums are doubtless the most valuable crop known for reviving the exhausted soil.

Aside from the length of the growing season and quantity of green material and seed produced, there are but minor differences in the development of the species, which are essential in selecting them for a cover or green-manure crop. The Florida velvet bean matures seed in the shortest period, 20 weeks from planting, and *Stizolobium velutinum* in the longest, after 33 weeks of growth. These results are from spring plantings. When planted at other seasons the time required for the plants to mature may be of different length, but the relative periods will be the same. Spring or early summer plantings are the only ones that will insure a heavy vine growth in sections where the summer rainfall is heavy and the winter drought severe, and they will result in a heavier growth than plantings at other seasons generally throughout the island. Fair crops may be expected from planting at any season if rainfall is sufficient and not excessive during the growing period. For heavy crops of vines they should be planted in a season of moderate rainfall during the spring so the vines and roots will be well developed before the occurrence of the heavy summer rains. When planted in the season described the vines cover the ground in a few weeks. From this time on the tangling of the vines makes cultivation impossible as well

as unnecessary. The rapid vine growth continues, the vines climbing over each other where no upright supports are in reach, forming a thick blanket of vegetation. This mat of vines, leaves, and seed clusters becomes 2½ or more feet in depth, if weather conditions are favorable, and immediately after harvesting weighs 10 to 15 tons per acre or more according to species. After the seed mature the vines make but little growth and die within a few weeks. The dying vines and leaves make an ideal mulch for protecting the soil from the intense sun heat and in dry periods keep the soil moist and loose a number of weeks after exposed areas are dry and hard. When worked into the ground the heavy growth of vines is valuable in retaining the moisture as well as in enriching the soil. For green manuring, the vines may be easily crushed down with a roller or disk harrow and should dry a few days before they are turned under.

The roots do not penetrate deeply into light soil and are seldom found more than a few inches from the surface in heavy, poorly drained lands. They are numerous and long and well set with large nodules.

The Stizolobiums are sensitive to drought and prefer a sandy loam soil, but in the climate of Porto Rico they will make an excellent growth on a great variety of soils if weather conditions are favorable. They have been grown on very heavy clay loam and on heavy and light sandy loam, and the plantings have in all cases given heavy crops.

For seed production some upright growing plant should be planted over which the vines may climb and hold the seed clusters free from the ground if the seed mature during a rainy season, as the heavy vegetation surrounding the seed clusters holds the moisture and they often decay if allowed to rest on the moist earth. The pigeon pea or gandul, as it is commonly called, makes an excellent support for the vines.

As all the species which have been cultivated here are very prolific, only a small area is needed for the production of seed unless they are grown for the market. (Pl. II, fig. 1.) The seed clusters may be harvested when the pods first show the color of maturity, or left in the field for weeks if dry weather prevails, as the seed pods are very tough and, although inclined to open, but few seed will be lost. The seed is not attacked by insects and retains its viability much longer than any other legume suitable for use as a cover crop except the Canavali. Eighteen months after harvest a high percentage of seed, which have been kept in open air, germinate.

The seed may be sown broadcast, but the best results are obtained when the planting is made in rows, which will permit of cultivation, as this is often made necessary for a few weeks after planting by

FIG. 1.—JACK BEAN (CANAVALI ENSIFORMIS).

FIG. 2.—SWORD BEAN (CANAVALI GLADIATA).

FIG. 1.—TYPICAL CLUSTERS, PODS, AND BEANS OF SIX VARIETIES OF STIZOLOBIUM.

1, *Stizolobium velutinum*, S. P. I. No. 24424; 2, *S. aterrimum;* 3, *S. cinereum;* 4, *S. velutinum*, S. P. I. No. 24657; 5, *S. niveum;* 6, *S. deeringianum.*

FIG. 2.—PIGEON PEAS AS TEMPORARY WINDBREAK FOR YOUNG CITRUS ORCHARDS.

FIG. 1.—LYON BEAN (STIZOLOBIUM NIVEUM) ON HEAVY SOIL.

FIG. 2.—STIZOLOBIUM VELUTINUM, S. P. I. NO. 24657, ON HEAVY SOIL.

FIG. 1.—MATRACA (CROTALARIA RETUSA).

FIG. 2.—HABICHUELA CIMARRONA (PHASEOLUS ADENANTHUS).

the growth of grass and weeds. By planting the seed 9 inches apart in the row and spacing the rows 3 to 3½ feet apart, 30 to 35 pounds of seed will be required for 1 acre.

Many planters are averse to planting velvet beans, fearing that the pods will be coated with long stinging hairs, as are the pods of *Mucuna pruriens*,[1] or "pica pica," as it is commonly called, which is well known throughout the island. The kinds discussed here produce pods which have but little down and that too short to be objectionable.

The Stizolobiums which have been tested in Porto Rico resemble each other closely for the first few weeks of their growth, but later develop differences in habit which are of importance to those contemplating using them for an economic crop. A short discussion of the habits of the different species recommended for cultivation is given below. Other species have been grown in test plats, but they were destroyed on account of the stinging hairs borne on the pods.

LYON BEAN (*Stizolobium niveum*).

The Lyon bean has, since 1910, been under observation at the experiment station and has been distributed to planters in many parts of the island. Wherever tested, it has given excellent results if the weather during the planting and growing season was favorable. (Pl. III, fig. 1.) Like other Stizolobiums, it grows best when planted in the spring. It is, with the exception of the Florida velvet bean, the earliest to mature of any of the species under discussion. Differing from its habits in Florida, where it matures at the same time as the Florida velvet bean,[2] it matures about one month later than that species on heavy soils at Mayaguez and six weeks later when grown on the sandy coast areas near San Juan. For a five or six month cover crop this is the most desirable of the Stizolobiums. It is a rank grower and a prolific seeder. The green weight from a spring planting harvested 140 days after seeding was 10.47 tons per acre, calculated from weights of the crop from representative sections of the field, and the dry weight of sun-dried material was estimated at 2.47 tons per acre. Its early maturity makes it less well suited for localities where the rainy season is long and unbroken.

BENGAL OR MAURITIUS BEAN (*Stizolobium aterrimum*).

This species, which is known commonly as the Mauritius or Bengal bean,[3] has been grown at the experiment station for the past three

[1] Cook and Collins. Economic Plants of Porto Rico. U. S. Nat. Mus., Contrib. Nat. Herbarium, vol. 8, pt. 2 (1903), p. 194.

[2] U. S. Dept. Agr., Bur. Plant Indus. Bul. 179, p. 17.

[3] U. S. Dept. Agr., Bur. Plant Indus. Bul. 179, p. 18.

years and has been distributed to farmers in all sections of Porto Rico. It is tolerant to a wide range of soils, and, wherever observed growing, it has been strong and thrifty if the rainfall was sufficient. It is one of the two most rank growers of the velvet beans cultivated by the station and is a prolific seed producer. Excepting the species *S. velutinum* and *S. cinereum*, the Mauritius bean has the longest growing season of the kinds tested here. Planted April 25 on heavy loam at Mayaguez, the first seed ripened in six months and the vines remained alive and maintained a good crop of leaves for over eight months. The growing period of this and other late maturing kinds was probably shortened by the severe winter drought, as the vines were thrifty and growing and gave no indications of maturity until the winter drought occurred.

One hundred and forty days after planting, the time the Florida velvet bean was considered to have its maximum growth, the *S. aterrimum* had produced 10.7 tons per acre of green material which, when sun dried, weighed 1.9 tons per acre, a yield considerably below that of the Florida velvet bean. Two hundred days after seeding the green weight produced was 16 tons per acre and the dry weight 4.3 tons. The roots of this species are larger than those of the others and, like them, grow very near the surface where the soil is wet or heavy. On sandy beach land, as well as on heavy soils, this velvet bean proved satisfactory as a cover or green manure crop and as a means of keeping out other vegetation. (Pl. VIII.)

STIZOLOBIUM CINEREUM.

With other species *S. cinereum* has been cultivated at the experiment station at Mayaguez since 1912. While the growth of this species is not as heavy as some others and is much slower during the first few weeks, the growing season is longer than that of any others except the *S. velutinum*. It is two or more months later in maturing seed than the Lyon bean and 2½ months later than the Florida velvet bean. It is a moderate seed producer, but much below other species in this respect. As a rule only two or three pods are found in a cluster, while in all other species they are numerous.

STIZOLOBIUM VELUTINUM.

Two varieties of this species, one, S. P. I. No. 24424, bearing seed which are reddish gray marbled with black, and the other, S. P. I. No. 24657, seed gray marbled with black, were sent to the experiment station in April, 1912, and have proved to be very thrifty and well suited to conditions here. (Pl. II, fig. 1.) Plantings made on heavy land at Mayaguez and on sandy soil near San Juan show that the growing season of these varieties is at least two weeks longer than

that of other species. The last seed to ripen on plants which were planted in the spring matured nine months after seeding. Both varieties produce a heavy crop of vines and leaves, but the variety S. P. I. No. 24657 is somewhat the more rank in growth and is not excelled in this respect by any other species. (Pl. III, fig. 2.) A field of this variety planted April 25 was still green January 30, over nine months after planting, although the drought, which started several weeks previously, was severe. The heavy supply of dying vines and leaves kept the soil beneath them in a moist, loose condition several weeks after the surface of barren ground, or areas which were at the same time planted to the Florida velvet bean or Lyon bean, was dry and hard. Variety No. 24424, while having as long a growing season as the other variety, does not make as heavy a growth, at least in heavy soils. This species is especially adapted for fields where the late maturing, heavy growth of vegetation is desired.

FLORIDA VELVET BEAN (*Stizolobium deeringianum*).

Stizolobium deeringianum, commonly known as the Florida velvet bean, was the first of this genus of plants to be cultivated commercially in Porto Rico, and is the only one that is well known. It was first planted as a cover crop in citrus orchards a number of years before other desirable species were introduced here. Although it succeeds well on a great variety of soils if weather conditions are favorable, it is best adapted to sandy areas where the extreme weather conditions do not have as marked a detrimental effect as on clay soils and cultivation may be given at any season. It is most seriously damaged by excessive moisture and makes the lightest growth in dry weather of any of the species under observation. Planted on a heavy clay loam in April at Mayaguez, the vines made a rapid, thrifty growth and blossomed in three and one-half months. The seed matured in five months, and soon after the leaves fell and the plants decayed. Plantings made on sandy soil matured two weeks earlier than those on heavy land. As the fall months are months of heavy rainfall, when cultivation is impracticable, the field is left to the ravages of weeds and grass. At the time the growth of the vines was considered at its maximum, 140 days after planting, a harvest was made to determine the weight of the vegetable matter. When freshly cut the vines, leaves, and seed weighed 10.80 tons per acre, and when thoroughly sun dried 2.45 tons per acre. Planted on the same type of soil in November the vine growth was very light, but a good crop of seed, which ripened in March and April, was produced. The velvet bean is not a heavy seeder in the rainy seasons, compared with the more lately introduced species, and the seed pods, which are less thick and tough, permit of a higher percentage of decay if they ripen during the wet weather.

PIGEON PEA OR GANDUL (*Cajanus indicus*).

This is doubtless the best-known legume growing in Porto Rico. It is cultivated in all parts of the island for its seed, which is used as a human food, and in many citrus orchards for the benefit derived by the trees. The total area devoted to the crop is, however, not large, as a small lot in the dooryard is sufficient to supply a family and leave a part of the crop for the nearest market. As the plants are prolific and the crop sure, the peas, which are sold for eating, are very cheap, and since very little culture is required, it is a favorite garden crop. Although used secondarily as a cover crop, it finds an important use in wind protection and protecting soil from washing, as well as in enriching it with nitrogen and humus. As a windbreak in a young citrus orchard the pigeon pea is almost indispensable in Porto Rico. It is an upright, bushy, woody plant, which grows 3½ to 4½ feet high in dry weather or on very poor soils, and reaches 11 to 12 feet on loam or sandy soil if the rainfall is plentiful. It proves a very satisfactory windbreak until citrus trees are three or more years old. (Pl. II, fig. 2.) When grown for this purpose they should be planted in the tree rows when the trees are young or before they are set, where they will provide wind protection and crowd out other vegetation in this area where it is inconvenient to cultivate. The blossoms should be removed to insure a heavy wood growth.

This plant is a strong feeder and should not be planted within a few feet of another valuable crop. The root system is penetrating, and while the roots are small they are numerous and spreading and efficient in preventing soil washing. The roots are well set with small nodules and through their decay are valuable for forming passages in the stiff subsoils. The woody stems decay slowly, but are good for forming humus.

The pigeon pea should be planted during the spring in drills 2 to 4 feet apart, and a few inches apart in the drill where planted to prevent erosion, as windbreak, or for killing out grass, and in hills 3 to 4 feet apart each way where planted for seed. The plants should be thinned to 1½ or 2 feet apart at the end of the first year if the windbreak is to be retained for two or more years.

As a rule the gandul, as the pigeon pea is commonly called in Porto Rico, is very popular and found in every market while in season. An analysis of the pulse is as follows:[1]

	Per cent.
Nitrogenous matter (albuminoids)	19. 83–20. 38
Starch or carbonaceous matter	61. 90–64. 32
Oil or fat	1. 10– 1. 12

[1] Watt, G. Dictionary of the Economic Products of India, vol. 2, p. 14. Calcutta, 1889.

VALUABLE WILD LEGUMINOUS PLANTS.

Of the large number of legumes growing wild over the island, there are a number possessing qualities which make them valuable in orchards or other cultivated lands and worthy of protection and in some instances of cultivation. These species, described below, and perhaps a number of others, after their long period of adaptation, are vigorous and thrifty and able to compete with the most vigorous weeds, and are often seen flourishing among them. With the exception of *Chamæcrista diphylla*, the wild leguminous plants have on most farms been included among the weeds and excluded from cultivated fields wherever possible, but they are found in abundance in uncultivated and uncared-for places such as pastures, roadsides, lawns, thickets, etc. In these places the soil is often poorly drained, hard, not fertile, and the legumes must compete with other wild vegetation. Their thrifty growth under these conditions indicates that with care they will prove to be valuable crops for general cultivation. Most wild legumes have the same growing period as the common field weeds, starting after the first spring rains and growing throughout the summer. They are exceptionally free from the attacks of injurious insects and plant diseases and are more resistant to drought than most weeds and remain green later into the dry season, becoming most conspicuous during periods of drought. It is not necessary that the seed, which ripens in late fall or winter, be harvested, stored, and planted in season, as it falls to the ground and germinates during the following spring.

As but few planters have familiarized themselves with the wild vegetation of the island, the following descriptions and illustrations, showing characteristic leaves, flowers, and seed pods, will enable one to identify at once the living plants of the same species and to recognize other varieties and species which are closely related.

These crops should be protected and encouraged on every plantation.

MANI CIMARRONA (*Chamæcrista diphylla*).[1]

This annual is found growing wild in many parts of the island and, unlike other wild legumes under discussion, is well known and its value is so generally recognized that it is included among the cultivated cover crops. During the past few years it has been used as a cover crop, and in small sections on the north side of the island it is a favorite for this purpose in citrus orchards. It grows best on fertile, sandy loam and has not been successful on heavy clay, but should be thoroughly tested in all parts of the island.

[1] Other native names are hediondilla, zarzabacoa, and sen de dos hojas.

Its growth is erect and branching, from 1 to 1½ feet tall in uncultivated land, and from 2 to 3½ feet where cultivation is given. The stems are slender and easily worked into the soil when mature. The slender, branching roots are spreading and penetrate well into sandy loam, and are therefore very valuable for preventing erosion. It is a good plant for adding nitrogen to the soil, as may be seen by the growth of the root tubercles, which, although small, are very numerous. The growing season for *C. diphylla* is from early spring to fall, and plantings made during fall or early winter have in all cases proved unsatisfactory. In soils suited to its growth it reseeds itself from year to year, and on land given cultivation a thick stand of plants appears in early spring. No cultivation whatever need be given the young plants, and after the seed mature the customary fall and winter cultivation may be given the land without consideration of the seed crop. This is an excellent cover crop for citrus orchards, and when a stand is once obtained in the orchard no expense is connected with its culture.

MATRACA (*Crotalaria retusa*).

An erect, woody plant found on both sandy and heavy soils. Growing wild, it has but few branches and is 6 inches to 3 feet high, but with cultivation makes a heavy, bushy growth and reaches 4½ feet in height. The flowers are bright and showy and of a longer duration than many tropical flowers, which makes the crop valuable ornamentally as well as for enriching the soil. In Porto Rico this species is most frequently found along the sandy areas near the seashore. Its growth for the first few inches after appearing above the ground is slow, but its extensive root system enables it to make a good development on poor soils, and it is therefore adapted to sandy areas where the sparse vegetation will not hinder its early growth. Its roots are heavily noduled, and the woody stems when worked into the soil decay slowly, furnishing a source of plant food over a long period. "In India this plant is often cultivated for its fiber, which is sold as a form of sunn hemp."[1] (Pl. IV, fig. 1.)

ZARZABACOA GALANA (*Desmodium adscendens*).

A wild beggar weed, closely related to the well-known beggar weed of the Southern States, although not of the same rank, erect growth. In exposed places the plants send up numerous short stems which have short internodes and bear a heavy crop of leaves. (Pl. V, fig. 1.) In these places the thick mat of leaves and stems often covers the ground. When growing among tall weeds and grasses the stems

[1] Watt, G. Dictionary of the Economic Products of India, vol. 2, p. 613. Calcutta, 1889.

have long internodes and attain a length of from 4 to 6 feet. The flowers are purple in color, but small and inconspicuous. This species thrives on a wide range of soils, including sandy loams and hard, barren heavy clays. It makes a good growth during the rainy season, and remains vigorous late into the winter drought. It blossoms from October until January. Its roots are very long and slender and well noduled, showing that it is a good nitrogen gatherer.

ZARZABACOA COMÚN (*Desmodium incanum*).

The flowering and fruiting of this species appear to the casual observer very similar to the species first discussed. The woody vines reach several feet in length, but are inclined to be creeping rather than climbing. Leaves have three leaflets—terminal ones 2½ by 1½ inches, lateral ones 1¾ by three-fourths inches. Growing in barren places, or in low grass, the vines are more branched and short, and the heavy growth of leaves covers the grass or ground. Growth and blossoming continues late into the winter. It thrives in wet weather, and remains green and thrifty after weeds and grass have been killed by drought. (Pl. V, fig. 2.)

HABICHUELA CIMARRONA (*Phascolus adenanthus*).

This plant is well known in all parts of the island and is most common on heavy soils. It is a rapid grower and thrives among weeds and grass. It is usually found growing in thickets and with rank-growing grasses. It climbs over other vegetation, and during the first dry weather it sometimes covers the other vegetation. It is prolific, spreads rapidly, and becomes valuable where protection is afforded. The vines are long and climbing; the leaves have three leaflets of about equal size, 3¼ by 2 inches. While there is much variation in shape, the central one is usually ovate and the lateral ones always unequally sided, about two-thirds of the leaflet area being below the midrib. The flowers, which are about an inch in diameter, grow closely together in a raceme, forming a showy cluster. (Pl. IV, fig. 2.) The root system is extensive and penetrating. "The tuberous root is cooked and eaten, especially in times of famine"[1] in India.

YERBA ROSARIO (*Æschynomene americana*).

Found in all parts of Porto Rico. It is most common in barren, uncultivated places, but, where protected, spreads rapidly. It makes an upright bushy growth 2 to 3 feet tall in hard dry soil, from 3 to 6 feet in cultivated places, and often forms thickets. The stems are woody near the base and slender and succulent at the tips. The

[1] Watt, G. Dictionary of the Economic Products of India, vol. 6, part 1, p. 186. Calcutta. 1892.

leaves are from 1 to 1½ inches long. The leaflets are numerous, as is seen in the illustration. (Pl. VI, fig. 1.) The flowers are yellow in color, small and inconspicuous, and appear in November and December. The seed ripens in two or three weeks after the blossoms fall, and the plants soon die. The roots are large, long, and spreading, and well set with tubercles.

CONCHITA PELUDA (*Centrosema pubescens*).

A slender-vined leguminous plant, usually seen growing along fences, near trees, or among other vines or weeds where protection from the cultivator is afforded. It is a very thrifty grower, is resistant to drought, and does best on heavy soil. Most of the blossoms appear in November and December, although the plants continue their growth until spring. As the blossoms are large and showy and of several days' duration, the plant would be valuable for cultivation as an ornamental. (Pl. VI, fig. 2.)

TAMARINDILLO (*Cassia chamæcrista*).

An upright growing plant attaining a height of 1½ feet when growing among grasses or on hard dry soil and 3 feet or more on cultivated soil. It is very resistant to dry weather and succeeds where weather and soil conditions are so unfavorable that other vegetation dies. The flowers are small and yellow in color. The roots are numerous and penetrating. On barren, heavy, poorly-drained clay this plant made the most satisfactory crop of any of the native legumes when planted side by side with them and given no cultivation. While the plants are small and return much less vegetable matter to the soil than many other species they are valuable in reclaiming exceptionally poor soils. (Pl. VII, fig. 1.)

HABICHUELA PARADA (*Phaseolus semierectus*).

An erect annual plant 1½ feet tall when grown in uncultivated places and 3 feet when under cultivation. It is found on both heavy and light soils and is not sensitive to either short droughts or periods of excessive rain. To test the species under cultivation a planting was made on a heavy, gravelly clay loam at Mayaguez. The seed was planted March 24, close together, in drills 3 feet apart. The rainfall during the spring was light, but the crop made a good growth and blossomed 45 days after planting. A satisfactory growth and blossoming continued until late in October, when the plants were over 3 feet in height. The growth of the cultivated crop was not dense enough to keep out weeds and grass during the weeks of heavy rains in August and September. (Pl. VII, fig. 2.)

FIG. 1.—ZARZABACOA GALANA (DESMODIUM ADSCENDENS).

FIG. 2.—ZARZABACOA COMÚN (DESMODIUM INCANUM).

FIG. 1.—YERBA ROSARIO (ÆSCHYNOMENE AMERICANA).

FIG. 2.—CONCHITA PELUDA (CENTROSEMA PUBESCENS).

FIG. 1.—TAMARINDILLO (CASSIA CHAMÆCRISTA).

FIG. 2.—HABICHUELA PARADA (PHASEOLUS SEMIERECTUS).

FIG. 1.—STIZOLOBIUMS AS COVER CROPS IN COCONUT PLANTATION. TYPICAL GROWTH IN SANDY SOIL.

FIG. 2.—SAME FIELD AS ABOVE AFTER DRYING OF VINES. NO WEED GROWTH.

MATO DE LA PLAYA (*Canavali obtusifolia*).

This plant is very common along the seashore of Porto Rico. It resembles in leaf and flower characteristics the cultivated species of the same genus. It has for many years been considered valuable as a cover crop and cultivated for that purpose. On light sandy soil it grows vigorously, sending out long creeping vines and an extensive root system, both of which assist in holding the soil which is naturally easily washed and blown. Its culture could be increased with profit in these places. The climbing vines make an excellent screen for light and wind, and for this purpose are often planted near verandas or windows. It is valuable also for planting ornamentally in sections where the soil is sandy, as it is prolific in reddish-purple flowers which are borne in racemes of 12 to 20 flowers each.

C. obtusifolia can be easily distinguished from *C. rusiosperma*, another wild species which is often seen climbing on trees, by its chestnut-brown seed. The latter species has large wine-colored seed.

COVER CROPS FOR CITRUS ORCHARDS.

In Porto Rico cover crops find their most important use in citrus orchards. Since the planting of the first commercial grove their need has been apparent, and at present they are found in a great majority of the orchards. The prevailing weather conditions with thorough cultivation cause rapid decay of vegetable matter and great loss of soil by surface washing, and, if not provided with vegetable matter for the formation of humus, the heavy lands devoted to orcharding become in a few years sticky in wet weather, hard and cloddy during drought, and turn from a dark to a reddish color. This has been well demonstrated in practice in Porto Rico. The area devoted to commercial citrus culture, with the exception of a few groves, is at present limited to the section on the north side of the island lying between Arecibo on the west to beyond Rio Piedras on the east and between the ocean and the mountains of the interior. In this section the rainfall is more or less uniform and sufficient for any cover crop, and while the soils devoted to orcharding include a variety of both sandy and clay types, all are capable of producing a luxuriant growth of some leguminous cover crop. Young citrus trees require much attention and with good care develop so rapidly that catch crops, except for pineapples, which are sometimes planted between young trees, are seldom planted. The cultivation given during the winter and spring months leaves the soil in excellent condition for the planting of cover crops. To serve their best purpose they should be planted at a time during the spring months that will allow them to make a heavy growth to protect the

soil from washing during the summer rains and from burning by the intense sun heat. In sections where rainfall is sufficient to maintain a satisfactory growth fall planting is sometimes practiced, but in bearing orchards the kinds that produce a heavy top growth prove a hindrance to the fruit harvest, while the injury to the growing fruit in preparing the land and seeding and in giving cultivation that may be necessary is considerable. Cowpeas, jack beans, a number of species of velvet beans, wild legumes, pigeon peas, and others are well suited to different soil conditions occurring in the citrus groves. These should be carefully tested to ascertain the kinds best suited to different localities. Those which make a heavy growth and are late maturing are the most satisfactory, as they may be planted during the spring and will keep down weeds and make cultivation unnecessary during the summer, when rainfall is heavy, and during the fall, when the trees are laden with fruit.

LEGUMINOUS CROPS FOR COCONUT GROVES.

Practically all coconut groves in Porto Rico are situated on sandy coastal plains. Due to the quality and fertility of this soil, many crops will flourish on it if cared for, and the cultivation, among the palms, of yuca, sweet potatoes, pigeon peas, and various other vegetables, has been a common practice for many years. These crops are cultivated for the seed or tubers, which are used for food rather than for improving the soil. While the cultivation given these catch crops may be beneficial to the palms, the crops are often cared for at their expense. As coconut trees must be set at wide distances apart, if good returns are expected over a long term of years, and require a number of years before fruiting, the cultivation expense per tree is so high that it is often neglected and the grass allowed to occupy the lands. In these places a heavy sod is formed, which hinders air circulation or water filtration in the soil and exhausts the fertility in the surface soil where the small, feeding coconut roots are most numerous. Where the sandy land is exposed to the sun the vegetable matter is soon burned out of the surface soil and the changing temperature of the sand makes an undesirable condition for the growth of the feeding roots. Until within the past few years the planting of cover crops in coconut groves was practically unknown in Porto Rico, but experiments with late-maturing, heavy-growing leguminous crops have shown that they are splendid crops for reducing the cost of cultivation, and insure excellent soil conditions for the development of the young palms. On the sandy soils devoted to coconuts cover crops should not be planted after the beginning of a severe drought, as the growth of the plants at this time is unsatisfactory. Spring and summer plantings of jack

beans, pigeon peas, cowpeas, or velvet beans have been satisfactory, while fall and early winter plantings have resulted poorly in the case of pigeon peas and cowpeas, and the other crops have produced small plants with only a fair seed crop. In old groves, when there is a good stand of palms, the shade is too dense for the crops just mentioned to flourish, although they are preferable to the wild growth commonly found in these places. Planted in such a grove near Mayaguez in June, the jack bean made a more satisfactory growth than the Florida velvet bean, the Clay cowpea, the pigeon pea, or the *Dolichos lablab*. The last-mentioned crop was the least satisfactory. Planted during the spring months in newly set groves, where there is a poor stand of palms and no shade to injure them, good crops of cowpeas, sword beans, jack beans, pigeon peas, and the different species of Stizolobiums previously discussed have been grown. Cowpeas planted under these conditions during April and May were very vigorous, a large percentage of the plants sending up vines which were 3 to 5 feet in length aside from the otherwise heavy growth. A good crop of seed ripened in three months after seeding. On account of the edible seeds and green pods, the cowpea is usually the first cover crop to be accepted by the coconut plantation owners. Differing from the practice on heavy soils, the cowpea may be planted during rainy seasons on sandy land. Here a good crop of both plants and seed will result, and the field may then be plowed and another crop planted.

The pigeon pea makes a thrifty growth on coconut land, and it is valuable for killing out wild vegetation and providing wind protection, which is very desirable for young coconut palms.

Sword beans and jack beans planted in coconut groves in different parts of the island in the month of April grew well, but the vegetable matter produced was much below that of several species of velvet beans, and the plants matured from two to three months earlier. Their growth was not sufficient to prevent the growth of wild vines and weeds, which are very persistent in many coconut groves.

Among the various crops tested, the Stizolobiums were the most satisfactory in young groves on account of their heavy growth and late development, which reduce the annual cultivation expense to a minimum. The species *S. velutinum*, *S. aterrimum*, and *S. cinereum* make about equal development and make a heavier growth and have a longer growing season than the Florida velvet bean or the Lyon bean. (Pl. VIII, fig. 1.) Planted April 7 in a young grove where the soil is a rich sand, the Florida velvet bean matured its seed and the dying plants were overgrown with wild vines by July 20. The Lyon bean made a heavier growth than the Florida velvet bean and matured one month later. The species *S. velutinum* matured nine

months after planting. During this period of growth the only attention required was the cutting back, at intervals, of the vines near the palms. The cover crops excluded all wild vegetation during the growing period, and the blanket of dead vines and leaves, which was several inches in thickness, prevented weed growth for a month after the maturity of the vines, when they were plowed under. (Pl. VIII, fig. 2.)

Great care must be taken that vines do not overgrow young coconut palms, as the resulting injury is severe. Young palms overgrown for less than three weeks were observed to be lighter in color when the vines were removed, and did not fully regain their color in six months. The growth of the leaves was also greatly retarded.

COVER CROPS WITH PINEAPPLES.

To test the effect of leguminous cover crops on pineapples, beds were set to Red Spanish and Cabezona varieties of pineapples, and with them were planted jack beans and pigeon peas. The land devoted to this experiment had been twice plowed and was in good condition for planting. In each bed four rows of pineapples were set, the plants 18 inches apart in the row and the rows 1 foot apart. The cover crops were planted the same day that the pineapple plants were set, and the number of hills of cover crops was the same as the number of pineapple plants. In planting the cover crops, the beds, which had 246 pineapple plants each, were divided into three sections, of which the center one was left for a check and duplicate plantings of the cover crops made in the end sections. In one end section of each bed the cover crops were cut during the early part of the dry winter season, about December 1, and not replanted until the end of the dry season in April. In the other sections they were cut whenever the seed matured and immediately replanted. The plants which were cut were placed on the beds between the pineapples. During the first summer of the experiments the most marked results were with the Cabezona variety where the pigeon peas were growing. The plants in this section were making but little growth and were not of a thrifty green color. Where the pigeon peas were growing with the Red Spanish variety the pineapples were not as green as in the check plat and the leaves were more slender. Where the jack beans were planted the pineapples were more upright and of a deeper green color, but the leaves and trunks of the pineapple plants were more slender.

One year after the experiments were started the effect of the cover crops was much more marked than at the beginning of the dry season, which had just ended. Where the jack beans had been growing throughout the year the plants of both pineapple varieties were

of a darker green color and more slender. The green color of the pineapples was doubtless the result of the shading by the cover crops. Where the jack beans were removed at the beginning of the dry season the pineapples were slightly more green than in the check plats, where they were very red. Where pigeon peas were grown with the Red Spanish variety the pineapples were not as thrifty as in the check plat and many of the plants grew but little after setting. The injury to the Cabezona variety was even more marked.

Two years after the beginning of the experiment the effect of the cover crops was seen to be injurious in every case. Where the pigeon peas had been cultivated continuously the injury was most severe. No fruits had been borne by the Cabezona variety and only exceptional plants made any apparent growth after the first few months from setting. The growth of the Red Spanish variety was somewhat more satisfactory than with the Cabezona. Where the pigeon peas were grown during the rainy season only, their effect on the pineapples was less marked. The jack bean was much less harmful to the pineapples, the least injury resulting where they were grown during the wet season only.

The cover crops were in every case injurious to the pineapples and are not recommended for planting in the beds with them. As the feeding roots of pineapples are short and dependent upon the plant food in the upper few inches of soil, they are easily starved by crops which feed at the same depth, and the conclusion reached coincides with that of many planters that clean cultivation is necessary for the best development of pineapples.

Leguminous crops, while harmful to pineapple plants when planted in the beds with them, may be used to advantage in pineapple culture. It is often the practice in Porto Rico to abandon the pineapple field for one or more years after a few crops of fruit have been harvested and longer cultivation of the plants is unprofitable, or, without giving it cultivation, to devote it to stock pasture. This leaves the soil of the pineapple beds, which after a few years of shallow cultivation becomes firmly packed and hard, in a condition that renders aeration and water filtration poor and hinders processes of disintegration. By plowing thoroughly and planting to a vigorous growing leguminous crop, preferably one of the late-maturing Stizolobiums, the mechanical condition of the soil would be improved, nitrogen and vegetable matter added, the land freed of objectionable vegetation, and the period necessary to rebuild the fertility required for another planting of pineapples shortened. Shortening the so-termed "resting" period in the high-priced pineapple lands would result in a great saving.

CULTURAL PRACTICE.

Where long-season cover crops are to be grown a deep, well-prepared seed bed should be made, and as the development of the crop will not allow cultivation after the first weeks of its growth, it should be stirred just previous to seeding so that the soil will not remain unworked longer than necessary and any wild growth on the land will be destroyed.

The choice of broadcasting or row planting will depend much upon the wild growth of the individual field. Where the land is free from grass and weeds broadcast seeding succeeds well, but where they are plentiful, as is usually the condition on recently reclaimed heavy lands, row planting, which will permit of cultivation until the cover crop is a few weeks old, is preferable.

For the best success, care must be taken that the planting is done at the proper season. Not only must the best growing season be considered, but the soil management as well. During the spring and early summer is the most desirable time for planting, as then both weather and soil conditions are favorable. Fortunately for the citrus growers, who by this time have finished their harvest and orchard cultivation, this is the most convenient time. An exact time of planting will depend upon the season of heavy rainfall in a respective section. March and April plantings are, as a rule, the most satisfactory. Young leguminous plants make a poor growth in wet weather, but if planted in the spring, where the rainfall is moderate, they will make sufficient growth within a few weeks to prevent erosion and fulfill their purposes during the summer. Where grown for seed, fall plantings give satisfactory results.

On fertile lands but little cultivation is required by the most vigorous cover crops, except for a short period after planting, but on hillsides or barren areas, where surface washing has carried off the surface soil, cultivation and fertilization should be practiced to insure a normal growth and a satisfactory return to the soil. Where the leguminous crops are not used as green manures they may be crushed down by a roller or disk harrow when mature or when they interfere with the fruit harvest, and worked into the soil at the convenience of the orchardist.

Resulting from the general distribution of the wild-growing legumes, most Porto Rican soils are inoculated with nodule-forming bacteria. Cultivated lands, where legumes have been excluded, or uncultivated grass lands are, however, not supplied with these bacteria and should be inoculated before planting a cover crop. Convenient and inexpensive ways of doing this are to mix soil which is known to be inoculated with the seed at the time of planting, or scatter it over

the field so that it can be worked in while seeding or while cultivating the young crop.

SUMMARY.

Lands devoted to horticultural crops in Porto Rico are very deficient in humus and vegetable matter, and are greatly damaged by surface washing.

Cover crops were first cultivated in Porto Rico by planters who became interested in citrus growing after the American occupation of the island.

There is a great difference in soil types and in local weather conditions, making the selection of a cover crop which will give most satisfactory results of great importance.

The cowpea is grown in all parts of the island. It has the shortest growing season of any of the legumes described in this bulletin. It is valuable as a cover crop and as a food.

The jack bean, although lately introduced, is in more general use than any other cover crop. It thrives on all except very light lands, and, on account of its habits of growth, is very desirable in citrus orchards.

The Lyon bean, the Mauritius bean, and a number of other lately introduced velvet beans succeed well on all types of Porto Rico soils where horticultural crops are grown. They are recommended for growing in open fields or for general use where care is taken to prevent injuries by the rank-growing vines.

The pigeon pea succeeds well in all parts of the island. It is cultivated for its edible seed and as a cover crop and windbreak. Under favorable conditions the plants continue their growth for a few years.

The thrifty annual legumes which are growing wild are valuable and should be protected and encouraged. They reseed themselves and are very resistant to drought and heavy rainfall.

The vegetable matter in Porto Rico lands devoted to citrus culture soon disappears when clean cultivation is practiced. The soil and climatic conditions favor the employment of cover crops throughout the sections where citrus fruits are grown.

In old coconut groves, where there is a good stand of trees, the dense shade prevents a thrifty growth of cover crops. In young groves, or where the stand of trees is poor, velvet beans, jack beans, and cowpeas are satisfactory cover crops. Cowpeas and pigeon peas are used both as cover and catch crops in coconut groves.

Pigeon peas and jack beans hinder the growth and production of Cabezona and Red Spanish varieties of pineapples when planted in the bed with them. The pigeon pea was more harmful than the jack

bean and the development of the Cabezona variety was retarded more than the Red Spanish.

Cover crops make their heaviest growth and serve their purpose best when planted in spring or early summer.

Nodule-forming bacteria are present in most Porto Rican soils. Where the bacteria are wanting, inoculated soil should be scattered over the field at the time of seeding the cover crop.

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY

△